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Piston engine, shaft and rolling bearing for a

piston engine
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The invention relates to a piston engine or a shaft or a
5 rolling bearing for a piston engine, in accordance with the
pre-characterising clause of claims 1, 10 or 15.

During the functional operation of a piston engine, there
are fed into the shaft of the piston engine transverse
10 forces which result from the forces of the piston and which
tend to bend said shaft. The shaft and at least two
appertaining pivot bearings therefore have to be
constructed in a sufficiently robust manner. In spite of a
robust construction and mounting of the shaft, bending of
15 the latter occurs because of the elasticity of the
material, a fact which leads to inclined positions of said
shaft in the region of the bearing sections, and that is
particularly the case when said bearing sections are at an
axial distance from one another. In the case of axial
20 piston engines, in particular, this distance is relatively
great and is determined by the axial dimensions of a
cylinder block and a drive disc.

On the subject of the technological background, reference
25 should be made to DE 102 20 610 A1, for example, with
regard to a plain pivot bearing in an axial piston engine.

Because of deflection and the resulting inclined position
of the relevant bearing section in the region of the pivot
30 bearing, an inclined position of the bearing ring in said
pivot bearing also automatically occurs, a fact which leads
not only to jamming effects in the pivot bearing but also
to one-sided loadings with correspondingly high surface
pressures (so-called "edge runners"). As a result of this,

the bearing surfaces are subjected to higher loads, a fact which leads to higher wear and to a reduction in the working life of the pivot bearings.

- 5 In piston engines, it is customary for the pivot bearings to be constituted by plain bearings or rolling bearings. Under these circumstances, it is likewise customary for the relevant bearing section of the shaft to be constituted by a cylindrical bearing section, on which a hollow-
10 cylindrical bearing sleeve is seated with a fit without radial clearance of motion.

The underlying object of the invention is to configure a piston engine or a shaft or an inner bearing ring for
15 mounting the shaft in the piston engine, in such a way that the working life of the relevant pivot bearing is prolonged.

This object is achieved by means of the features in claims
20 1, 10 or 15. Advantageous further developments of the invention are described in the appertaining subclaims.

In the piston engine according to the invention in accordance with claim 1, the axial length of the supporting
25 region is shortened to a central region of the bearing section, and radial play is present between the bearing section and the inner bearing ring in the two outer regions next to said supporting region.

30 In the configuration according to the invention in accordance with claim 10, the axial length of the supporting region is shortened to a central region of the bearing section, said bearing section having a greater

diameter in its axial central region than in its outer regions.

In the configuration according to the invention in accordance with claim 15, the axial length of the supporting region is shortened to a central region of the inner bearing ring, and said bearing ring has a diameter, in the two outer regions next to the supporting region, which is smaller than in the outer regions.

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The configurations according to the invention lead to the fact that, when the shaft and/or the inner bearing ring is/are in the assembled condition, a radial clearance of motion is present in the outer regions between the bearing section and the bearing ring, while a central region of the bearing section and of the bearing ring fulfils the necessary supporting function. Because of the radial clearance of motion in the outer regions, there are present, on both sides of the shortened supporting region, clearances into which the bearing section is able to move in the event of deflection of the shaft, without radial compression stresses occurring in the end regions of said bearing section. Consequently, the jamming effects and elevated surface pressures which arise in the case of the prior art are also avoided, and the wear of the pivot bearing is reduced and its working life increased.

The bearing section also moves into the clearances present on both sides, when the inner bearing ring is fitted onto the driving shaft in the heated-up condition with over-dimensioning.

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The length of the shortened supporting region may amount to about $1/4$ to $1/2$, and in particular to about $1/3$, of the

length of the bearing section or bearing ring. Tests have shown that these dimensional ranges lead, on the one hand, to a sufficiently large supporting region and, on the other hand, to sufficiently large clearances on both sides of
5 said supporting region. The supporting region itself may be of cylindrical construction on its superficies.

On the bearing section, the outer regions may be constituted by longitudinal regions of the relevant bearing
10 section which are step-shaped or continuously narrowed towards the outside. In comparable manner, the outer regions on the bearing ring may be constituted by widened portions that diverge in a step-shaped manner or towards the ends of said bearing ring.

15 The configurations according to the invention are suitable both for a plain bearing and also for a rolling bearing. In both cases, the supporting force of the bearing is transmitted, via the inner bearing ring, to the supporting
20 region of the bearing section or of the bearing ring, or vice versa. The configurations according to the invention are particularly highly suitable for a needle bearing in which the radial bearing play is particularly low and therefore even small deflections of the shaft lead to the
25 loadings on the pivot bearing which have been described above. It should also be emphasized that rolling bearings are particularly sensitive to radial jamming effects and pressure peaks because of the small size of the running surfaces.

30 Advantageous configurations of the invention will be explained in greater detail below with the aid of preferred exemplified embodiments and drawings. In the latter:

Figure 1 shows an axial piston engine according to the invention, in axial section;

Figure 2 shows a bearing region of a drive shaft of the axial piston engine, in side view;

Figure 3 shows a bearing section of the drive shaft, in side view;

Figure 4 shows the bearing section according to Figure 3 with an inner bearing ring pushed on; and

Figure 5 shows a bearing section according to the invention with an inner bearing ring seated thereon, in a modified configuration.

The exemplary piston engine, which is designated, as a whole, by 1, has a housing 2 in whose interior 3 a swash plate 4 and a cylindrical drum 5 are disposed side by side. Disposed in said cylindrical drum 5, in a manner distributed uniformly over the periphery, are piston holes 6 which, in the present exemplified embodiment of an axial piston engine, extend substantially parallel to a central axis 7 of the cylindrical drum 5 and are open on that end face 5a of said cylindrical drum 5 which faces towards the swash plate 4. Mounted in a substantially axially displaceable manner in the piston holes 6 are pistons 9 which are preferably cylindrical and which, with their piston heads 9a, delimit working chambers 11 in the cylindrical drum 5 in the direction of the swash plate 4. The foot ends 9b of the pistons 9, which foot ends face towards said swash plate 4, are each supported on the latter by a joint 12, under which circumstances sliding blocks 13 may be present, between which blocks and the foot

ends 9b are disposed the joints 12, which are preferably constructed as ball joints 12 with a spherical head and a spherical recess.

5 The cylindrical drum 5 rests, with its end face 5b that faces away from the swash plate 4, against a control disc 14 in which two control apertures 15 in the form of through-holes are disposed, which constitute sections of a diagrammatically indicated supply line 16 and a discharge
10 line 17, which lines extend through an adjoining housing wall 18 on which the control disc 14 is held. The cylindrical drum 5 is mounted on a drive shaft 19 which is rotatably mounted in the housing 2 and whose axis of rotation 21 extends coaxially in relation to the central
15 axis 7.

In the present exemplified embodiment, the housing 2 is formed from a pot-shaped housing part 2a with a housing bottom 2b and a peripheral wall 2c, and also a cover 2d
20 which constitutes the housing wall 18 and which rests against the free edge of said peripheral wall 2c and is screwed to the latter by screws which are represented in a diagrammatic manner. Line connections 16a, 17a are provided on the cover 2d for the purpose of connecting the
25 onward-going supply and discharge lines 16, 17.

The drive shaft 19, which passes through the cylindrical drum 5 in a bearing bore 23, is rotatably mounted and sealed in bearing recesses in the housing bottom 2b and the
30 cover 2d by means of suitable pivot bearings 25, 26, for example plain bearings or, in particular, rolling bearings, said shaft passing axially through the housing bottom 2b and protruding from the latter with a drive pin 19a.

In the present exemplified embodiment of the piston engine 1 as a swash-plate engine, the cylindrical drum 5 is disposed in a non-rotatable manner on the drive shaft 19 by means of a rotary-entrainment connection 27, for example a toothed clutch, the said drive shaft passing through the swash plate 4, which is disposed fixedly on the housing bottom 2 or constructed therein, in a through-hole 4a. In the present exemplified embodiment, the cylindrical drum 5 rotates, when in functional operation, relative to the swash plate 4, the pistons 9 being displaced longitudinally in the direction of the working chambers 11 and back.

In the exemplified embodiment according to Figure 2, the pivot bearing 25 in the housing bottom 2a is constituted by a rolling bearing, for example a ball bearing, and the pivot bearing 26 in the cover 2d by a rolling bearing, in particular a needle bearing.

The bearing sections of the drive shaft 19 which carry the inner bearing rings 25a, 26a are designated by 19b, 19c. Within the scope of the invention, one of the two pivot bearings 25, 26 or both the pivot bearings 25, 26 may be constructed in the manner which will be described below with the aid of Figures 3 to 5 in the case of the pivot bearing 26 in the cover 2d.

In the configuration according to the invention, the bearing section 19c is narrowed in cross-section on both sides of a central section a. These outer regions which are located next to the central section a are designated by b and c. The narrowed portion may be one which is step-shaped or one which extends in a manner converging towards the particular end of the bearing section 19c. In the present exemplified embodiment, the outer regions b, c are

cylindrical outer regions b, c which are narrowed in a step-shaped manner. The central section is preferably likewise of cylindrical construction. It constitutes a supporting region 28 for the inner bearing ring 26a.

5 Compared with known configurations, said supporting region 28 is axially shortened to the central region a, and is, for example, of cylindrical construction. The axial size of the supporting region 28 amounts to about $1/4$ to $3/4$, and preferably $1/3$, of the length L of the bearing section
10 19c. The radial dimension d of the narrowed portion amounts to 0.05 mm, at least in the end region of the outer regions b, c.

In the supporting region 28, the bearing ring 26a is seated
15 on the bearing section 19c with a fit without radial play, which fit is customary for the inner bearing rings of rolling bearings. Because of the radial clearance of motion, annular clearances 29a, 29b are present between the narrowed superficieses of the outer regions b, c and the
20 cylindrical inner superficieses of the bearing ring 26a. In the event of bending B, which is represented in a diagrammatic manner in Figure 2, of the drive shaft 19, the end regions of the relevant bearing section 19c are able to dip into the clearances 29a, 29b without exerting jamming
25 effects and compression stresses on the bearing ring 27a.

If the supporting region 28 is of cylindrical construction, slight compression stresses can occur with the bearing ring 26a can occur in the event of deflection of the drive
30 shafts 19 in the supporting region 28, as a result of which said bearing ring 26a can be stretched outwards slightly in its central region, as Figure 4 shows diagrammatically in chain-dotted lines.

The exemplified embodiment in accordance with Figure 5, in which parts which are the same or comparable are provided with the same reference symbols, differs from the exemplified embodiment described above through the fact
5 that it is not the bearing section 19c but the bearing ring 26a which has, in its central region a, the supporting region 28a, next to which in the outer regions b, c said bearing ring 26a is widened internally, either in a step-shaped manner or in a manner diverging towards its ends.
10 This results, in each of the outer regions b, c, in radial play, or an annular clearance 29a, 29b, between the cylindrical superficies of the bearing section 19c and the outer regions b, c. In the event of deflection of the drive shaft 19, the end regions of said bearing section 19c
15 are able to dip into these clearances 29a, 29b, with the advantages described above.